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Laboratory Tests of Air-Measuring Bags and Disk-Valve Hand Pump for Mine Dust Sampling Apparatus.

By G. E. McElroy, Assistant Sanitarian, United States Public Health Service.

The experiments here reported were conducted by the writer at the Pittsburgh, Pa., and Golden, Colo., stations of the Bureau of Mines, under the personal direction of Mr. A. C. Fieldner, supervising chemist; and were made during the period April 30 to May 31, 1919, inclusive.

Two sets of tests were conducted, as follows:

I. Tests of air-measuring bags for use with a breathing type of dust-sampling apparatus.

II. Tests of a disk-valve hand pump as motive power for dust-sampling apparatus.

I. TESTS OF AIR-MEASURING BAGS FOR USE WITH BREATHING TYPE OF DUST-SAMPLING APPARATUS.

The objects of these experiments were to calibrate and to determine the general adaptability of large-capacity air-measuring bags for use with a breathing type of dust-sampling apparatus for mine work.

General Statement.

A breathing type of dust-sampling apparatus, until this time considered standard for the Bureau of Mines, is equipped with an air-measuring bag made of light-weight rubberized fabric, having a capacity of slightly over 1 cubic foot, and which, when uninflated, is approximately 5 feet long by 12 inches wide. Previous tests have shown a maximum error of 10 per cent in air measurement with this bag. Also, with such a small capacity, a minimum of 12 to 14 bagfuls would be required for a good sample, necessitating an inconvenient amount of manipulation as regards connecting, disconnecting, and emptying the bag.

To overcome the foregoing difficulties it was thought probable that a 15 cubic foot bag, approximately cylindrical when inflated, could be used. A bag of rather heavy rubberized fabric of the same material as that adopted by the Army for air pillows was procured. This bag was 5 feet long and 3 feet 4 inches wide, uninflated. A few preliminary trials showed, first, that the bag when inflated was too large for convenient handling; second, that, the width of the bag being greater than the width of the material, a seam had been placed about 6 inches from one side which made it impossible to roll the bag up evenly on a stick, a necessary requirement if the bag is to be entirely emptied; and third, that the opening for a connection at the top had been made much smaller than specified.

In view of these facts, the original bag was cut down to 4 feet 9 inches by 28 inches, uninflated dimensions, and, as remodeled, is designated as bag No. 1.

As soon as the approximate volume of bag No. 1 had been secured, a rough calculation was made to determine the dimensions of a bag having a volume of approximately 8 cubic feet, and two bags of the calculated dimensions and made of light-weight rubberized fabric were procured. These two bags are as nearly as possible identical, and are designated as bags Nos. 2 and 3, respectively.

Apparatus.

An American Meter Co. dry meter, type 5-light B, was connected to the inlet end of a new standard sugar tube, the outlet of which was connected, both with and without the intervention of the mouth-breathing parts of the present standard apparatus, to the bags designated as Nos. 1 and 2, each bag having been fitted with a metallic connection piece with water-gauge attachment.

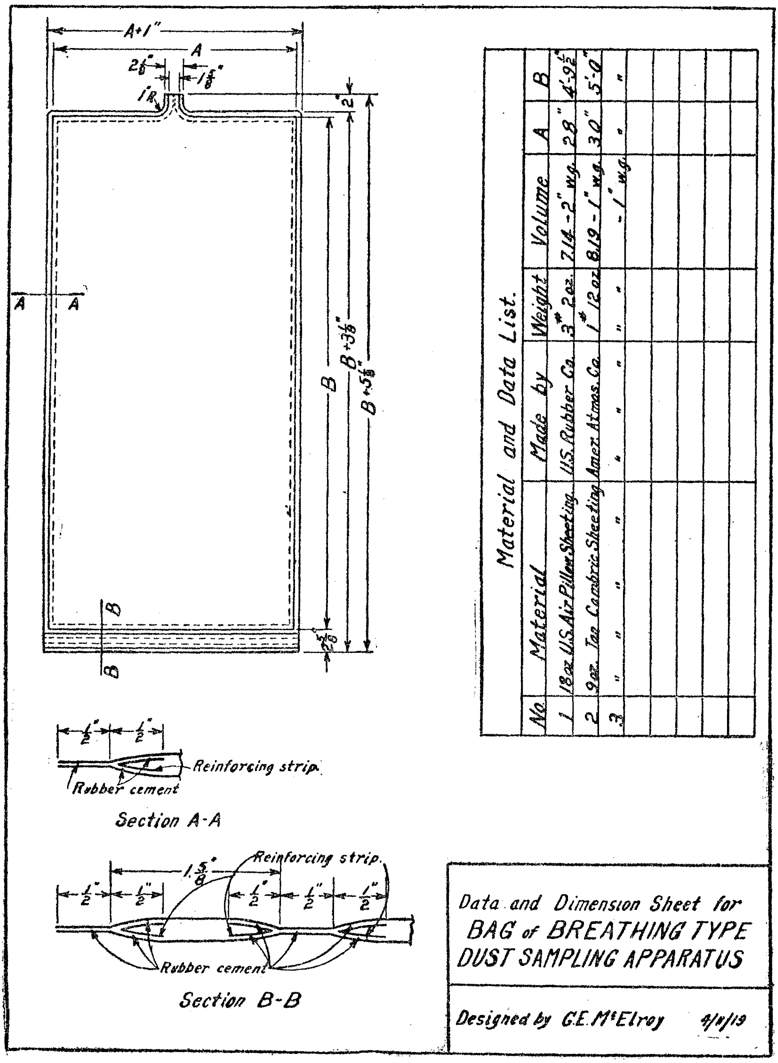
The dimensions and other data regarding bags Nos. 1 and 2 are given in Figure 1. The apparatus and photostat copies of drawings of the new standard sugar tube and of the new connection pieces are shown in Figures 2, 3, 4, and 5.

Results of Tests.

Bag No. 1.—Direct calibration of the bag by passing air at slight pressure through the meter and sugar tube into the bag gave volumes of 7.27 to 7.35 cubic feet when filled to 2 inches water-gauge pressure, with an average of 7.32 cubic feet for six trials. In this test the bag was rolled up very carefully each time on a flat surface.

Calibration of the bag in use, by measurement of the amount of air sucked through the tube necessary to fill the bag to 2 inches water-gauge, the bag having previously been rolled up while held vertical, gave volumes of 7.08 to 7.20 cubic feet, with an average of 7.12 cubic feet for six trials, or a maximum plus or minus error of about 1 per cent. To fill the bag required from 10 to 14 minutes, at 0.04 to 0.10 cubic feet per breath. Room temperatures were varied from 63° F. to 80° F. The temperature of the air in the bag was determined immediately (about 20 seconds) after the bag was full by suspending a thermometer in the outlet of the disconnected bag and forcing the air out. As measured, the excess in temperature of the air in the bag over that of the room varied approximately inversely as the temperature, being 6° at 63° F, and 2° at 80° F. It was noted that about 0.25 cubic foot was required to raise the pressure in the bag from 1 inch water-gauge to 2 inches water-gauge. Two inches water-gauge pressure was required to completely distend the bag, although distention was practically complete at 1 inch water-gauge.

Bag No. 2.—Calibration of the bag in use was carried out in the same manner as that for bag No. 1, except that on account of the bag being of lighter material it was filled to but 1 inch water-gauge pressure.



Material and Data List.

No.	Material	Made by	Weight	Volume	A	B
1	18oz. U.S. Air Pillow Sheeting	U.S. Rubber Co.	3# 2 oz.	7.14-2" w.g.	28"	4'-9½"
2	9oz. Tan Cambric Sheeting	Amer. Atmos. Co.	1# 12 oz.	8.19-1" w.g.	30"	5'-0"
3	" " "	" " "	" "	-1" w.g.	"	"

Data and Dimension Sheet for
BAG of BREATHING TYPE
DUST SAMPLING APPARATUS

Designed by G.E. McElroy 4/11/19

FIG. 1.

Six trials of 11 to 14 minutes' duration gave volumes of 8.14 to 8.25 cubic feet, with an average of 8.19 cubic feet, or a maximum plus or minus error of approximately 1 per cent.

Measurements of the increase in bag temperature over room temperature for room temperatures of 62° F. to 73° F., gave 2° to 3° increase, the amount of the increase apparently being independent of the temperature.

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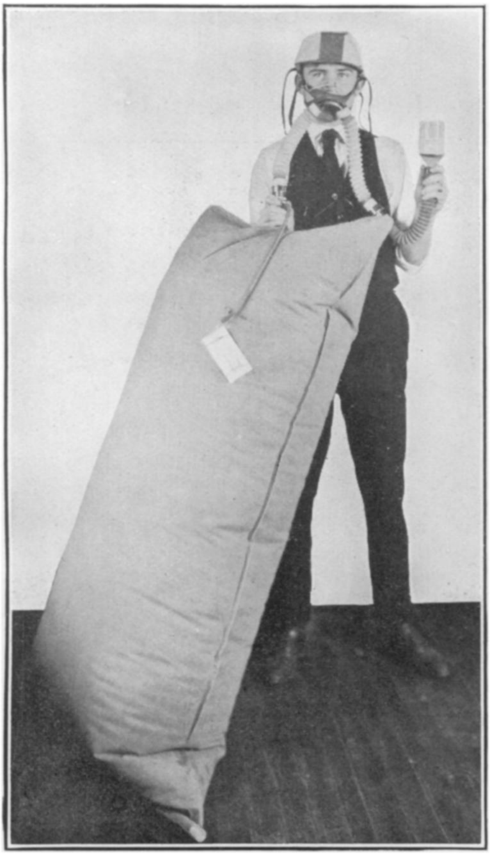

FIG. 2.

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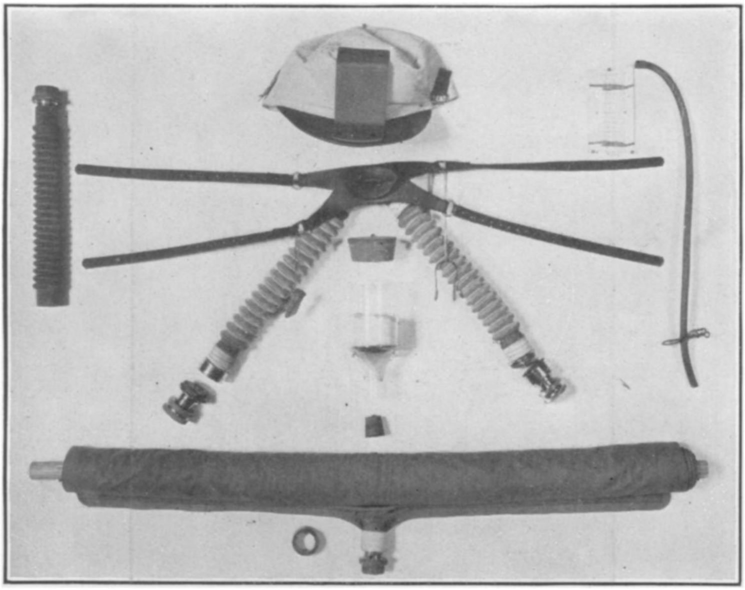


FIG. 3.

Remarks and Conclusions.

It appears feasible to use bags of rubberized fabric of as much as 8 cubic feet capacity for air measurement with a breathing type of dust-sampling apparatus.

Bags made of light-weight tan cambric sheeting are preferable to bags made of the heavier air-pillow sheeting on account of their lighter weight, better heat dispersion of the included air, and the fact that they can be made with the rubberized side of the fabric outside. However, it is probable that the cambric sheeting may not prove strong enough for mine work. In handling a bag of this material it is necessary to keep the tip of the water-gauge tube connection covered with rubber tubing to prevent accidentally puncturing the bag.

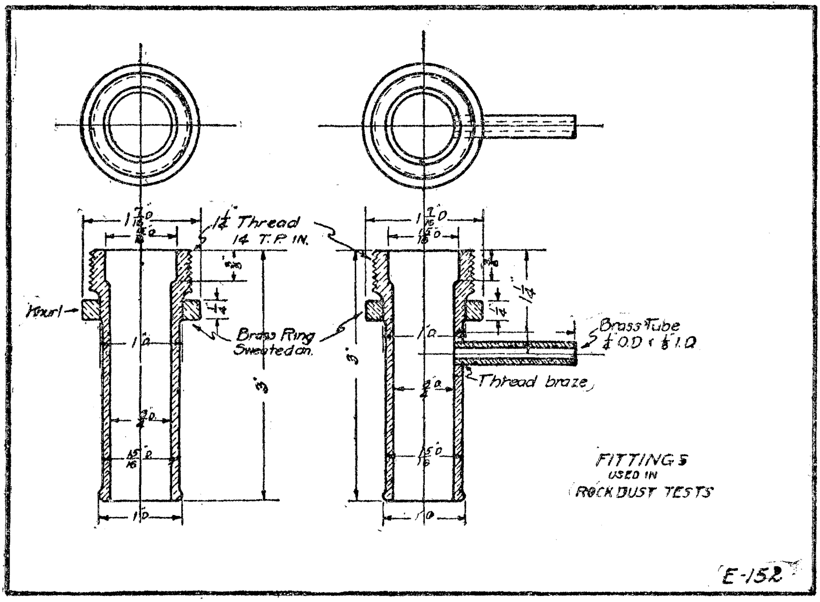


FIG. 4.

Extensive use of bags of this capacity (8 cubic feet) may show that a shorter and wider bag would be more convenient to handle.

These tests indicate that bags of this nature and size can be used to measure the air sucked by breathing through a standard sugar tube, with an error of 1 per cent or less, an accuracy comparable to that of standard dry meters.

It is necessary to fill bag No. 1 to 2 inches water-gauge pressure to secure proper distention; while with bag No. 2, on account of its lighter weight, but 1 inch water-gauge pressure is required. In each case it seems very likely that the end point could be determined with sufficient accuracy—that is, within 2 per cent—without referonce to a water gauge except, occasionally, as a check. No experiments have been conducted as yet to support this statement.

A certain amount of air is trapped in the bag each time it is rolled up, but this amount is practically constant and is properly accounted for when the calibration obtained by breathing the bag full is used.

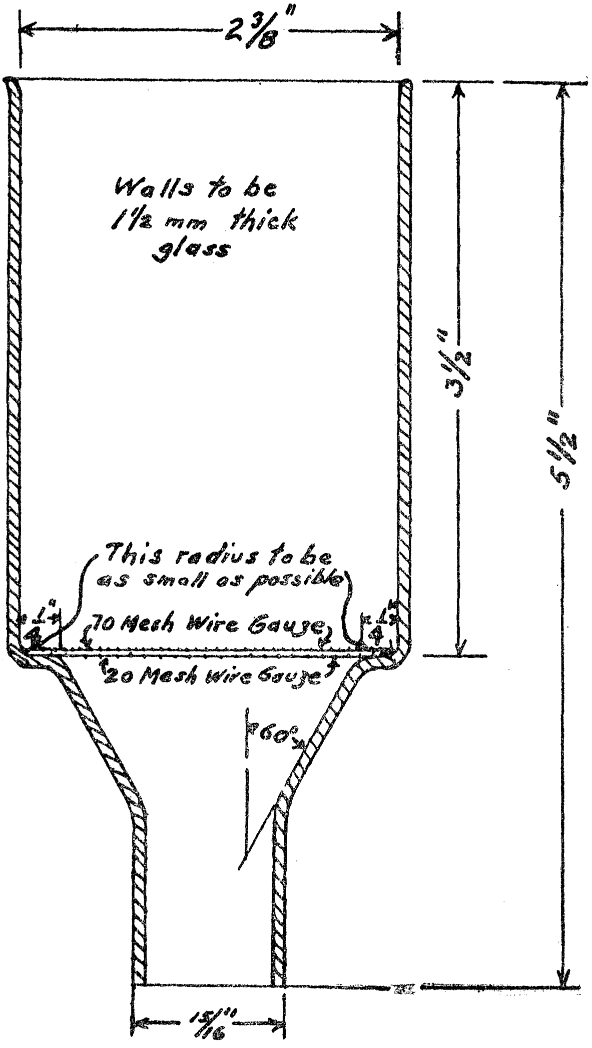

2 3/8"
Walls to be 1½ mm thick glass
3½"
5½"
This radius to be as small as possible
1/4"
1/4"
70 Mesh Wire Gauze
20 Mesh Wire Gauze
60°
15/16"

FIG. 5

By using the figure obtained by breathing the bag full and measuring the air going into the sugar tube the correct figure for the amount of air sampled is obtained, regardless of the fact that the volume of air in the bag may actually be a greater or less amount.

Log of Tests.—Bureau of Mines Laboratory, Pittsburgh, Pa.

A. *Direct calibration of bag No. 1.—Bag filled to 2 inches water-gauge pressure—Air at slight pressure run through meter and standard sugar tube into bag—Bag rolled up evenly on flat surface before each trial—May 14, 1919, p. m.*

Cubic feet by meter.	Time elapsed.
7.27	6
7.32	8
7.28	8
7.31	10
7.32	8
7.35	9
[1] 7.32	[1] 8

[1] Average.

B. *Calibration of bag No. 1 by breathing bag full to 2 inches water-gauge pressure, using standard sugar tube—Bag rolled up while hanging vertically—May 15, 1919, a. m.*

Cubic feet by meter.	Time elapsed.	Room temperature.	Temperature of air in bag at end point.	Difference of temperature.
		°*F.*	°*F.*	°*F.*
7.08	13	80.0	82.0	2
7.08	10	76.5	79.0	2½
7.14	11	76.5	79.0	2½
7.08	13	72.0	75.0	3
7.16	11	63.0	69.0	6
7.20	14	69.0	72.0	3
[1] 7.12	....	....	....	....

[1] Average.

C. *Calibration of bag No. 2 by breathing bag full to 1 inch water-gauge pressure, using standard sugar tube—Bag rolled up while hanging vertically—May 15, 1919, p. m.*

Cubic feet by meter.	Time elapsed.	Room temperature.	Temperature of air in bag at end point.	Difference of temperature.
		°*F.*	°*F.*	°*F.*
8.15	13	73.0	76.0	3.0
8.17	11	73.0	75.0	2.0
8.14	12	66.0	69.0	3.0
8.25	12	64.0	66.5	2.5
8.22	12	62.0	65.0	3.0
8.20	14	62.0	64.5	2.5
[1] 8.19	[1] 12	....	....	[1] 2.7

[1] Average.

II.—TESTS OF DISK-VALVE HAND PUMP AS MOTIVE POWER FOR DUST-SAMPLING APPARATUS.

These tests were carried out to calibrate and to determine the general adaptability of a disk-valve hand pump for use as motive power for dust-sampling apparatus for mine work.

General Statement.

A ball-valve hand pump, modeled after the type used in South Africa for dust-sampling work, had been found by test to be very hard to manipulate and of widely varying capacity when operated at varying speed. The pump was, therefore, remodeled and the ball valves with their small-diameter connecting ports were replaced by disk valves with large-diameter connecting ports.

Apparatus.

A working drawing of the disk-valve pump is shown in Fgure 6, and photographs showing the pump in use and the set-up for calibration purposes in Figures 7 and 8. The pump itself weighs 15 pounds. The wooden carrying case containing the pump and accessories weighs 36 pounds.

Results of Tests.

Preliminary 3-minute calibration tests made at the Bureau of Mines laboratory, Pittsburgh, Pa., on the pump as received from the instrument maker, gave uniformly varying capacities of 0.0994 cubic foot per double stroke at 12 strokes per minute to 0.1031 cubic foot at 30 strokes per minute. The pump was then disassembled and shipped to Golden, Colo.

Upon reassembling the pump it was found that the casing of the two inlet valves was not tight, thereby making preliminary calibration tests void. It was noted also that the diaphragm was loose, but it was not tightened at this time.

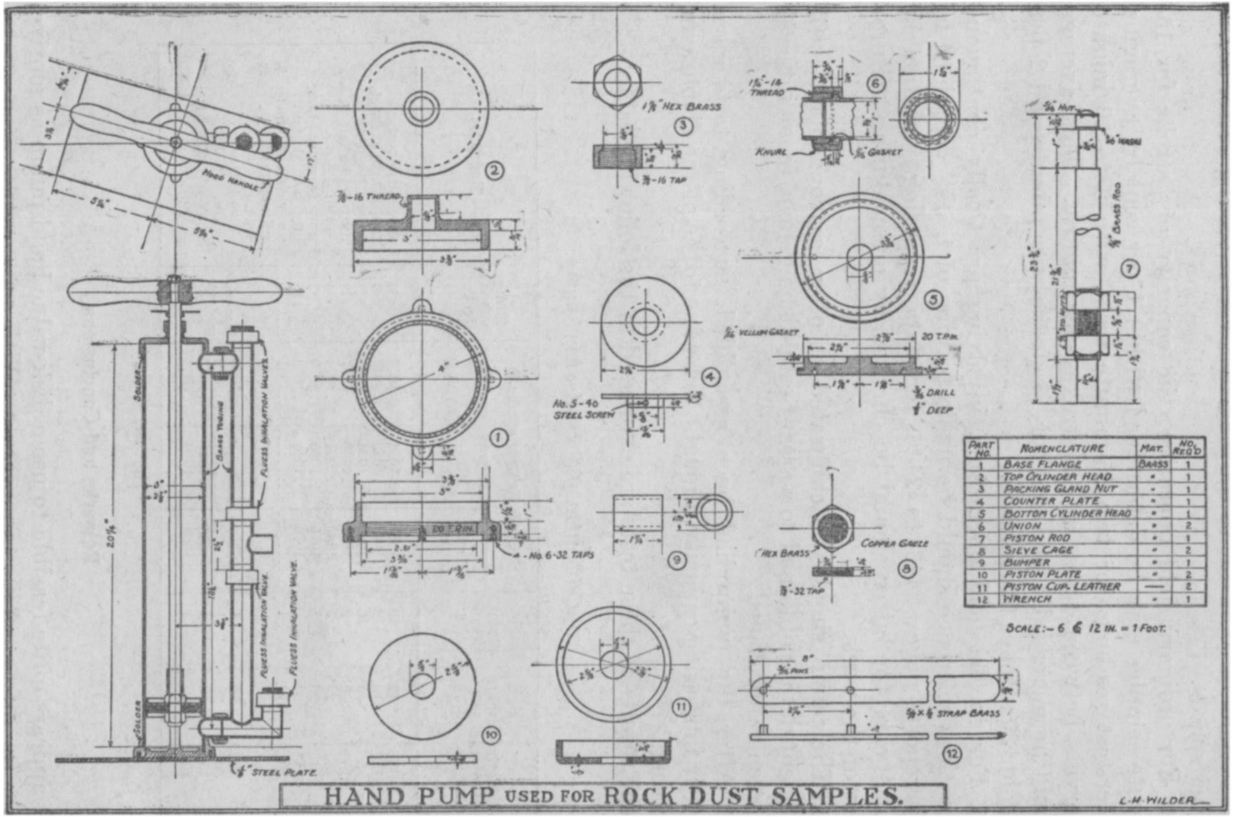
Further 3-minute calibration tests gave such variable results that the pump was taken apart, cleaned, and the diaphragm tightened and well oiled with medium heavy machine oil.

A large number of calibration tests were then conducted, in which the number of strokes per minute, the total time of operation, and the time interval between tests were varied at will. These tests were all conducted at the Bureau of Mines laboratory at Golden, Colo., in *quiet* atmospheres.

The results of these tests can be expressed as follows:

1. The capacity per stroke increases with the speed, being approximately 2 per cent higher at 20 strokes per minute than at 12 strokes per minute.

2. The capacity per stroke decreases slightly as the time of continuous operation increases, until a point is reached, dependent upon the speed of operation, at which the capacity becomes practically constant. The amount of this decrease is uncertain at 12 strokes per minute, due to greater variations in capacity. At 15 strokes per minute the decrease amounts to about 1 per cent between 5 and 15 minutes' operation and but little over 1 per cent between 5 and 30 minutes' operation. (This effect is mainly due to increased temperatures in the pump barrel due to friction, and the amounts mentioned would probably be much less in moving air currents.)



PART NO.	NOMENCLATURE	MAT.	NO. REQ'D
1	BASE FLANGE	BRASS	1
2	TOP CYLINDER HEAD	"	1
3	PACKING GLAND NUT	"	1
4	COUNTER PLATE	"	1
5	BOTTOM CYLINDER HEAD	"	1
6	UNION	"	2
7	PISTON ROD	"	1
8	SIEVE CAGE	"	2
9	BUMPER	"	1
10	PISTON PLATE	"	2
11	PISTON CUP. LEATHER	—	2
12	WRENCH	"	1

SCALE:— 6 @ 12 IN. = 1 FOOT.

FIG. 6.

3. Greater variations were recorded at 12 strokes per minute than at higher speeds, the variation decreasing as the speed was increased. This is thought to be due to the mica disk valves setting better at the higher speeds.

4. For ordinary field operation, the capacity per stroke for 15-minute samples may be determined within 1 per cent by averaging meter-test readings for two 15-minute tests, with 5 to 10 minute intervals between tests, at 12 strokes per minute. This average should be increased 1 per cent for 15 strokes per minute and 2 per cent for 20 strokes per minute.

5. For special field operations, involving practically continuous operation, reference should be made to "log of tests" contained in this report, pages 2443 to 2446, for data regarding variation in capacity, or the latter should be checked by meter during the progress of the work.

6. The pump should be calibrated as often as convenient until sufficient data is obtained to warrant establishing a *maximum* interval between calibrations.

7. After the pump had been assembled, succeeding tests gave slightly increasing capacity, thought to be due to the piston diaphragm "setting."

The results of these tests are expressed in the following table:

Calibration of disk-valve hand pump.

Length of test, minutes.	Strokes per minute.	Number of tests.	Cubic feet per stroke.			Time between tests, minutes.	Remarks.
			Maximum.	Minimum.	Average.		
3	12	10	0.1061	0.1044	0.1050	(1)	Consecutive tests.
15	12	2	.1043	.1042	.1043	(1)	Pump warm at start.
3	15	10	.1060	.1044	.1051	(1)	Consecutive tests.
15	15	2	.1038	.1036	.1037	(1)	Pump cold at start.
3	20	5	.1080	.1067	.1074	3	Do.
3	20	5	.1075	.1065	.1070	3	Pump warm at start.
15	20	2	.1070	.1068	.1069	110	Pump cold at start.
30	12	1	....	....	.1051	....	Pump cold at start; 5-minute readings. (See log).
30	15	1	....	....	.1055	....	Do.
30	20	1	....	....	.1070	....	Do.
15	12	4	.1056	.1041	.1047	5	Pump cold at start.
15	15	4	.1069	.1059	.1062	5	Do.

[1] Time not noted.

Remarks and Conclusions.

It appears quite feasible to use a disk-valve hand pump as motive power for dust-sampling apparatus. With care, results accurate to within 1 per cent can be obtained with an apparatus of this type.

The pump used in these tests is rather heavy and cumbersome for mine use, and of too large a capacity for taking samples efficiently

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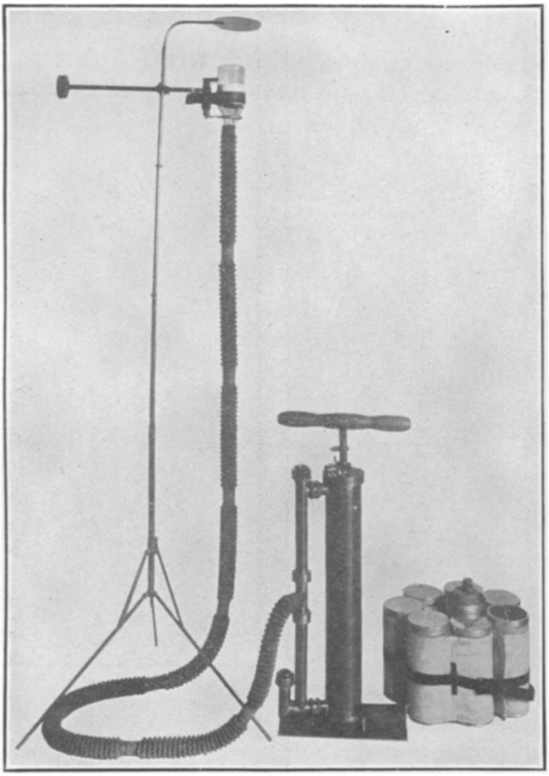

FIG. 7.

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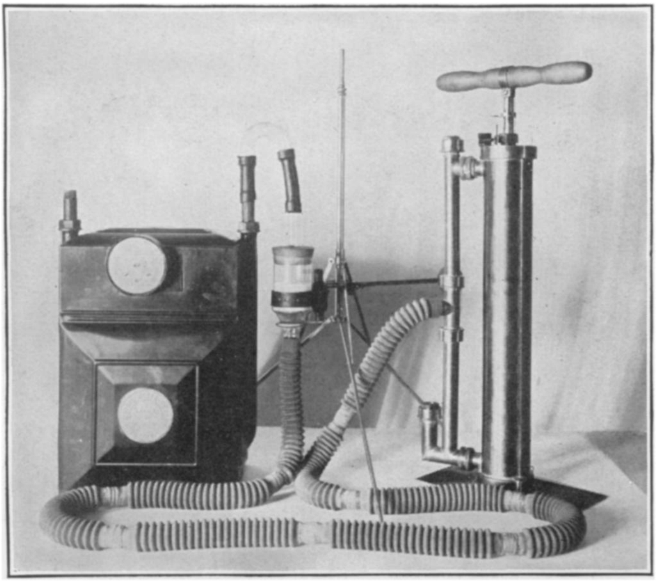

FIG. 8.

at the rate of 1 cubic foot a minute. For the latter rate of sampling, a pump of smaller capacity, lighter, and not so cumbersome could easily be designed. If such a pump were made of aluminum, the decrease in weight would be an advantage.

At a speed of 12 double strokes per minute the mica disk valves do not seat as effectively as they do at speeds of 15 to 20 strokes per minute, a fact that can be detected by the ear.

A pumping speed of about 20 double strokes per minute seems to be what might be called a normal speed, and can easily be maintained for from 10 to 15 minutes without undue fatigue with the pump used in these tests, the diaphragm of which had been well oiled.

The pump is so easily operated that the only fatigue noted is that due to bending over for each double stroke. This fatigue should be eliminated in future designs, if possible, by limiting the length and elevation of the stroke to that which may be accomplished by movement of the arms alone.

Each time that the diaphragm is replaced the piston should be rotated freely and worked for as long a time as possible before calibrating for actual use in order to give the diaphragm a good "set."

The pump-valve parts should be removed frequently and examined for the presence of dirt and especially of sugar.

Each time the pump is used after a considerable interval, such as a day or more, the counter device should be checked to make sure that it is functioning properly. When the piston is at the end of the down stroke, its most compact form, the spring of the counter device is in tension, and if allowed to remain in this position for a long time it may become too weak to function properly.

LOG OF TESTS.—Calibration of disk-valve hand pump. Model No. 1, pump No. 1.

Series No. 1.—Bureau of Mines laboratory, Pittsburgh, Pa., May 15, 1919—Pump as received from instrument shop—(Diaphragm loose, inlet valves leaking)—Time between tests not noted—G. E. M. and A. C. F.

Length of tests, minutes.	Strokes per minute.	Cubic foot per stroke.
3	11	0.0994
3	11	.0994
3	27.3	.1007
3	22	.1017
3	12.7	.1000
3	27	.1013
3	30	.1031
3	23.7	.1020
3	15	.1002
Interval of one-half hour.		
3	12	.1006
3	11.7	.0997

Series No. 2.—Bureau of Mines laboratory, Golden, Colo., May 24, 1919—Inlet valves tight; no leaks; diaphragm loose—Consecutive tests—Time between tests not noted.

Length of test, minutes.	Strokes per minute.	Cubic feet per stroke.
3	14	0.1060
3	12	.1036
3	15	.1062
3	10	.1025
3	19	.1058
3	13	.1053
3	12	.1006

Series No. 3.—Bureau of Mines laboratory, Golden, Colo., May 26 and 27, 1919—Pump taken apart, thoroughly cleaned, diaphragm tightened and oiled with medium heavy engine oil, and reassembled—Time interval between tests not noted—Tests run consecutively.

MAY 26, A. M.

3-minute tests at 12 strokes per minute.	15-minute tests at 12 strokes per minute.
0.1047	0.1042
.1061	.1043
.1050	[1] .1043
.1053	
.1047	
.1044	
.1050	
.1047	
.1047	
.1050	
[1] .1050	

[1] Average.

MAY 26, P. M.

3-minute tests at 15 strokes per minute.	15-minute tests at 15 strokes per minute.
0.1053	0.1036
.1058	.1038
.1047	[1] .1037
.1047	
.1047	
.1060	
.1056	
.1047	
.1047	
.1044	
[1] .1051	

[1] Average.

A 15-inch Centigrade thermometer was strapped to outside of pump barrel, and another Centigrade thermometer was hung near inlet to meter. Rotation of handle was limited by counter device to about 10° each way from normal.

[In the following table the position of the handle (and diaphragm) is indicated thus: — normal; / 10° to left; \ 10° to right; * varied. Pump was operated at 20 strokes per minute.]

MAY 27, P. M.

Length of tests, minutes.	Time.	Position.	Cubic feet per stroke.	Room temperature.		Pump temperature, °C.	Indicated difference in temperature, °C.
				°F.	°C.		
3	a. m. 10.17 10.20	—	0.1080	72	22	22.0 24.0	0.0-2.0
3	10.22 10.25	/	.1078	72	22	23.5 24.5	1.5-2.5
3	10.27 10.30	\	.1075	72	22	24.5 26.0	2.5-4.0
3	10.32 10.35	*	.1067	72	22	26.0 27.0	4.0-5.0
3	10.37 10.40	—	.1068	72	22	26.5 27.0	4.5-5.0
3	10.57 11.00	/	.1075	72	22	24.0 25.5	2.0-3.5
3	11.02 11.05	\	.1070	72	22	25.5 26.5	3.5-4.5
3	11.07 11.10	*	.1075	72	22	26.5 27.0	4.5-5.0
3	11.12 11.15	—	.1065	72	22	26.5 27.5	4.5-5.5
3	11.17 11.20	*	.1067	72	22	27.0 28.0	5.0-6.0
15	11.40 11.55	*	.1070	73	23	24.5 28.5	1.5-5.5
15	p. m. 1.45 2.00	*	.1068	73.5	23	23.5 28.0	[illegible].5-5.0

Average of 3-minute tests, 0.1072.
Average of 15-minute tests, 0.1069.
Pump temperature 24.5° at 2.20 p. m.

Series No. 4.—Bureau of Mines laboratory, Golden, Colo., May 27 and 29, 1919—30-minute tests; readings at 5-minute intervals.

12 STROKES PER MINUTE. MAY 27, 1919.

Time.	Time elapsed, minutes.	Cubic feet per stroke—average for interval of—			Room temperature.		Pump temperature, °C.	Indicated difference in temperature, °C.
		5 minutes.	15 minutes.	30 minutes.	°F.	°C.		
p. m. 3.30					75.5	24.0	24.5	0.5
3.35	5	0.1047			75.5	24.0	25.5	1.5
3.40	10	.1047			75.5	24.0	26.5	2.5
3.45	15	.1060	0.1051		75.5	24.0	27.0	3.0
3.50	20	.1060			75.5	24.0	27.3	3.3
3.55	25	.1038			75.5	24.0	27.5	3.5
4.00	30	.1055	.1051	0.1051	75.5	24.0	27.5	3.5

Pump temperature normal in 20 minutes.

15 STROKES PER MINUTE. MAY 29, 1919.

3.00					72.0	22.5	22.5	0.0
3.05	5	0.1067			73.0	23.0	25.0	2.0
3.10	10	.1063			73.0	23.0	26.5	3.5
3.15	15	.1055	0.1062		73.0	23.0	27.0	4.0
3.20	20	.1052			73.0	23.0	27.5	4.5
3.25	25	.1047			73.0	23.0	28.0	5.0
3.30	30	.1048	.1049	0.1055	73.0	23.0	28.0	5.0

20 STROKES PER MINUTE. MAY 29, 1919.

4.10					75.0	24.0	24.5	0.5
4.15	5	0.1079			75.0	24.0	26.0	2.0
4.20	10	.1071			75.0	24.0	28.0	4.0
4.25	15	.1069	0.1073		75.0	24.0	29.0	5.0
4.30	20	.1069			75.0	24.0	29.0	5.0
4.35	25	.1067			75.0	24.0	29.2	5.2
4.40	30	.1066	.1067	0.1070	75.0	24.0	29.4	5.4

Pump temperature 24.5° at 5.20 p. m.

Series No. 5.—Bureau of Mines laboratory, Golden, Colo.; May 30 and 31, 1919—15-minute tests at 5-minute intervals.

12 STROKES PER MINUTE. MAY 30, 1919.

Time.	Cubic feet per stroke.	Room temperature.		Pump temperature, °C.	Indicated difference in temperature, °C.
		°F.	°C.		
a. m. 11.16 11.31	0.1056	68.5	20.5	21.0 23.5	0.5-3.0
11.36 11.51	.1046	68.5	20.5	22.5 24.0	2.0-3.5
11.56 12.11	.1041	68.5	20.5	23.0 24.5	2.5-4.0
12.16 12.31	.1043	68.5	20.5	23.5 24.7	3.0-4.2

15 STROKES PER MINUTE. MAY 31, 1919.

a. m. 10.50 11.05	0.1069	65.5	18.5	19.0 22.5	1.0-4.0
11.10 11.25	.1061	65.5	18.5	21.5 23.0	3.0-4.5
11.30 11.45	.1059	65.5	18.5	22.0 23.5	3.5-5.0
11.50 12.05	.1059	65.0	18.0	21.5 23.5	3.5-5.5

THE WEIL-FELIX REACTION AS A LABORATORY TEST IN THE DIAGNOSIS OF TYPHUS FEVER.

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The Weil-Felix reaction, which has recently come into use as a means of diagnosing typhus fever, is of special interest in that an organism which has not been shown to be etiologically concerned in the disease can nevertheless be used for the diagnosis of typhus fever in the same way that the typhoid bacillus is used in the diagnosis of typhoid fever by the well-known Widal test. Whether it may ultimately be shown that the reaction is due to the presence as secondary invaders of the Proteuslike organisms which are used in the test, or whether it is entirely nonspecific, the reaction is still a very useful one for the reason that no satisfactory laboratory method of diagnosing typhus fever, aside from animal inoculations, had previously been discovered.

A recent article in the Journal of Hygiene by N. Hamilton Fairley (1)[1] on the laboratory diagnosis of typhus fever, calls attention to the significance and value of this reaction which was first investigated by Weil and Felix (2)[1] in 1915. A number of cases in east Galicia were encountered by these workers, which strongly resembled typhoid

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[1] Number indicates reference cited.